Image/Video Compression

Image/Video Compression

raw/uncropped

input

Encoder

Decoder

Channel coder

Channel decoder

1. 2 way image/video com vs. 1 way

Interactive TV

Symmetric encode/decode. Video companies

low delay. live encoding

1 way → streaming → "high delay" 7-10 sec.

4-25-03
Issues in compression are

1. Low delay: vs. medium delay
   - conferencing
   - vs. "no delay constraint"
   - DVD

2. Large delay -
   - Storage, expensive
   - Start up is affected
   - More wait is interactive applications
   - Fewer rebuffering

3. Symmetry, encode/decode

4. Compression efficiency
Compression Efficiency

1. What To Code

- DCT
- JPEG (original 1992)
- JPEG2000 (wavelets)

Video
- DCT
- H.261
- H.263
- MPEG-1
- MPEG-2

Packetizers

- Discrete Trigon Coll
- Wavelet Coll

- Pixel Intensity

- Fourier Transform Coll
- Discrete Trigon Coll
- Wavelet Coll
- Coeffs

- Orthogonal Dec
- Non-Ortho Oversynth Dec

- Fractal

- Model Based Coding

- Planets
1. Quantize: 2 bits

Uniform quantization: bins are of equal size.

Nonuniform quantization: bins are nonuniform (i.e., not equally sized).

R → Q → \( \frac{256}{N} \)
Bit assignment:

- 00
- 01
- 10
- 11

Uniform bit assignment:

Real \( \log_2 N \)

Finite size assignment shorter (fewer bits) codewords to more frequent symbols/letters

Alphabet \( \sigma = N \) symbols
\( N \) letters

A codeword
Finite size alphabet $\Rightarrow$ Entropy:

$$H = \sum_{i=1}^{N} p_i \log p_i$$

Some 2 letters: $a$, $b$

1. $p(a) = 0.99$
   $p(b) = 0.01$

2. $p(a) = \frac{1}{2}$
   $p(b) = \frac{1}{2}$

---

$aaaaaaaaba
\begin{align*}
0.99 \cdot \log_2 0.99 + 0.01 \cdot \log_2 0.01
\geq 0
\end{align*}$

$a\ b\ a\ b\ b\ a\ a\ a\ a\ a\ a\ a\ a\ a\ a\ a\ a\ a$
Inf. Theory: \[ \text{Entropy is} \]

Theoretically, minimum possible average bit rate you get for any source.

Huffman: A way of doing bit 1950 assignment to your finite-size alphabet some

Arithmetic code rate, with Huffman, is within 0.866 bit of entropy

[\text{Prob of most frequent symbol}]

\[ P_{\text{max}} \]

[0.01] [0.04] [0.05]
iid source = identically independent
independent identically distributed

\[ \{ a_1, a_2, a_3 \} \]
\[
\begin{align*}
p(a_1) &= 0.45 \\
p(a_2) &= 0.02 \\
p(a_3) &= 0.03
\end{align*}
\]

Entropy = \( \sum_i p_i \log p_i \approx 0.335 \) bits/symbol

Huffman = 1.05 bits/symbol

Huffman 213% of entropy.

\[ \rightarrow \text{Arithmetic coding} \]
A random variable \( P(f) = \text{pdf for variable} \).

\[ J = \# \text{ of recon. levels} \]

\[ f_{\text{min}} < f < f_{\text{max}} \]

\( r_i \): reconstruction level.

\( d_i \): boundary decision.

\( \hat{f} = \text{recon value for } f \text{ at receive} \)

\[ \sum_{i=1}^{r} \]

\[ \min \text{imize. } r_i, d_i \]

\[ E = E \left[ (f - \hat{f})^2 \right] \]
\[ E = \int_{f_{\text{min}}}^{f_{\text{max}}} \rho(f) (f - \hat{f})^2 \, df \]

\[ E = \frac{1}{2} \sum_{j=0}^{J-1} (f_j - r_{j+1})^2 \rho(f) \, df \]

\[ \frac{\delta E}{\delta \mathbf{r}_j} = 0 \]

\[ \frac{\delta E}{\delta \mathbf{d}_j} = 0 \]

\[ r_j = 2d_j - r_{j-1} \]

\[ r_j = \frac{\int_{d_j}^{d_{j+1}} f \, p(f) \, df}{\int_{d_j}^{d_{j+1}} \rho(f) \, df} \]